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Chapter 16

SETI Science: A Search Is Born*

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Abstract

In 1959, a landmark article in *Nature* marked the beginning of the modern observational Search for Extraterrestrial Intelligence. Over the next quarter-century, the field of study now known as SETI emerged out of the realm of science fiction, entering the scientific mainstream. This overview of that 25-year period is neither complete nor comprehensive, but rather representative of SETI progress during the discipline's formative years. Although the author concentrates primarily on early SETI history in the U.S., he encourages scientists from the rest of the world to document their progress—and that of their colleagues, as well.

I. An Idea Whose Time Had Come

It was an idea whose time had come, but nobody dared admit that out loud. Frank Drake, in particular, was keeping silent. Like many of his generation, he had long speculated about the existence of extraterrestrial life, and pondered how we humans might probe for direct evidence of our cosmic companions. Now, in

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1959, the young astronomer was finally in a position to do more than ponder. At 29, he had just completed graduate school, the ink on his Harvard diploma as wet as he was behind the ears. As the new kid on the block at the National Radio Astronomy Observatory, he had access to the tools necessary to mount a credible search for radio evidence of distant technological civilizations. Drake knew enough to tread lightly; a publicly announced hunt for Little Green Men would be tantamount to professional suicide. So, he approached his superior with understandable trepidation.

Fortunately, NRAO director Otto Struve was sympathetic, even as he counseled caution. Having theorized that the slowed rotation rate of certain stars suggested that their angular momentum had been dissipated in the formation of planets, Struve himself speculated on the probable existence of extraterrestrial civilizations. So, he authorized Drake to use the 85-foot diameter Howard Tatel telescope in his off-duty time, to conduct what was to become the world's first observational SETI experiment. Only, do so quietly, Struve warned; we don't want the word getting out that we're using a government facility to hunt for aliens.

Drake had already run the numbers. He knew the most likely frequency on which to search, and the best receiver circuitry to employ. He had picked his candidate stars, two nearby sun-like ones which he reasoned were likely to harbor habitable planets. He had selected his research methodology, and proceeded (very quietly) to assemble his listening station.

II. The Cat's Out of the Bag

And then, the *Nature* article hit the newsstands.* "Searching for Interstellar Communications" was written by two Cornell University professors, Giuseppe Cocconi and Philip Morrison, and it proposed, in brief but clear detail, the very experiment which Drake was preparing to conduct! This very first scientific article in the not-yet-named discipline of SETI was complete, down to the selection of frequencies and target stars—and it paralleled Drake's work exactly. Neither the team of Morrison and Cocconi, nor that of Drake and Struve, knew anything about the others' interest in this esoteric study. Both groups had arrived at the same crossroads in history, completely independently, in an elegant example of what I like to call the Parenthood Principle: when a great idea is ready to be born, it goes out in search of a parent. Sometimes, it finds more than one.

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* Giuseppe Cocconi and Philip Morrison, "Searching for Interstellar Communications," *Nature*, Vol. 184, No. 4690 (19 September 1959), pp. 844–846.

Now, Schrodinger's Cat was out of the bag, and Drake had no choice but to go public. The publicity he received was widespread, and generally enthusiastic; the scientific community, it appeared, was ready to embrace the notion of SETI. Struve began writing about the possibility of extraterrestrial life:

> An intrinsically improbable event may become highly probable if the number of events is very great...it is probable that a good many of the billions of planets in the Milky Way support intelligent forms of life. To me this conclusion is of great philosophical interest. I believe that science has reached the point where it is necessary to take into account the action of intelligent beings, in addition to the classical laws of physics.

His cover now blown, Drake soon found himself in the company of other open-minded scientists and technologists, who collectively found themselves unwitting parents to a newly emerging scientific discipline. Among those contacting Drake after reading about his nascent experiment were microwave communications expert Bernard M. Oliver, then vice-president of engineering at Hewlett-Packard (and, later, president of the Institute of Electrical and Electronic Engineering); Dana Atchley, president of Microwave Associates in Massachusetts; and a young planetary scientist, Berkeley post-doctoral researcher, Carl Sagan. These individuals, as well as Struve, Morrison, and a handful of others, were ultimately to become SETI's patriarchs.*

III. The First False Positive

Drake named his search Project Ozma, after the princess of Oz in the L. Frank Baum books, as he saw his efforts leading humans to a far-off and exotic land. Launched in April of 1960, and running only through May of that year, Ozma searched but two stars, on a single frequency, for mere dozens of hours, but established the protocols, and laid the groundwork, for all subsequent SETI experiments. It was a paradigm-shifting endeavor, successful for its audacity, if not for its discoveries.

And yet, for one brief moment early on, Frank Drake thought he had hit pay dirt. As he slewed his antenna off Tau Ceti and onto Epsilon Eridani, he was greeted with a strong, periodic, pulsed signal on 1420 MHz, the hyperfine transition emission line of interstellar hydrogen atoms proposed by Cocconi and Morrison, and still favored as a promising hailing frequency for interstellar communications. "My god," Frank mused, "can it really be this easy?"

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* Cocconi, though having co-authored the seminal SETI article with Morrison, went on to distinguish himself in particle physics research at CERN, never to return to the SETI fold.

The next day, when the signal reappeared, Drake was ready with a second, low-gain antenna. The pulses were there as well, sadly disproving their extraterrestrial origin. But they were not exactly terrestrial interference, either. The rate at which the phantom signal traversed the sky suggested that it was emanating from an aircraft cruising at unprecedented altitude—perhaps eighty thousand feet! Of course, in April of 1960, no known aircraft could reach the stratosphere. Such an aircraft, as it happened, didn't "come into existence" until the following month, when Francis Gary Powers was shot down over the Soviet Union.*

IV. Order of the Dolphin

A year after Project Ozma's brief tenure, Drake convened the first scientific conference devoted to modern SETI at the National Radio Astronomy Observatory's Green Bank, West Virginia observatory, 1–3 November 1961. He gathered together ten scientists from disparate disciplines to spend a week contemplating areas from the physical, biological, and social sciences which had relevance to the question of extraterrestrial technological civilizations, and how to communicate with them. The assembly included the six SETI patriarchs already mentioned, along with J. Peter Pearman of the National Academy of Sciences' Space Science Board, Su Shu Huang of NASA, University of California chemist Melvin Calvin (whose Nobel prize was to be announced during the Green Bank meeting), and neuroscientist John C. Lilly, who was then studying the language of dolphins, and attempting to communicate with these intelligent Earth mammals. The group called themselves the Order of the Dolphin, a tribute to Lilly's studies into human-dolphin communication, which they deemed a worthy metaphor for the challenge of interspecies communications on a grander, cosmic scale.

Drake chalked on a blackboard seven topics for discussion, which would comprise the agenda for the week-long meeting. They included stellar formation, planetary formation, the existence of planets within habitable zones, the emergence of life, the evolution of intelligence, communications technology, and the longevity of technological civilizations.

Having established that the emerging discipline of SETI was to encompass fields as diverse as stellar evolution, planetary astronomy, environmental science, biology, anthropology, engineering, and sociology, Drake next did something

* Frank wisely decided to withhold publication of this positive result, so he never did receive proper credit for "discovering" the U-2.

almost whimsical, which assured his lasting fame: he strung these seven factors together into an equation.

The idea was to multiply seven unknowns together, and in so doing, to estimate N, the number of communicative civilizations in our Milky Way galaxy. The Drake Equation, as it is now called, appears in every modern astronomy textbook. It is a marvelous tool for quantifying our ignorance: never intended for quantification, but quite useful in narrowing the search parameters. We still use it, not to seek a numerical solution, but rather to help us to focus our thinking in designing our searches for life.

Drake's seven factors are cleverly ordered, from solid to speculative. Today's astrobiology meetings are similarly structured. When the equation was first published, only the first factor (the rate of stellar formation) was known to any degree of certainty. In the intervening decades, Drake's equation has guided our research in an orderly manner, from left to right, so that today we have a pretty good handle on Drake factors two and three (planetary formation, and habitable zones). The remaining four factors are still anybody's guess, and it may well take decades more before our research begins to quantify those areas of our ignorance. But the Drake Equation is most valuable in guiding our research, because it asks the important questions. It is still up to us to answer them.

V. The Impact of Ozma

The lessons learned during the brief course of Project Ozma, amplified and expanded at the Order of the Dolphin meeting, have informed and enriched every subsequent SETI experiment. The interdisciplinary nature of the science now known as SETI was articulated at the outset. Drake's work clearly showed that Earth's technology was at last approaching the level at which a disciplined search for extraterrestrial microwave emissions was becoming feasible. The quietest part of the electromagnetic spectrum was explored then, as now. Highly directional, high gain parabolic antennas, coupled to very low noise microwave preamplifiers, remain our preferred observational tools. Although the advent of multi-channel spectrum analyzers means we no longer have to select a single channel to scan, SETI scientists continue to speculate as to universal calling frequencies that alien civilizations might employ to make their presence known. Concentrating our efforts on known, nearby sun-like stars remains an accepted technique for planning targeted searches, one of the two primary search modalities still practiced.

Most important, Frank Drake's early efforts began to lend legitimacy to an endeavor previously considered fringe science. Today, the preponderance of in-

formed opinion holds that we inhabit a universe teeming with life. The only matter for speculation is whether we yet possess the technology necessary to detect it. The emphasis here is on *yet*. Most of us contemplating such detection no longer argue "if," but rather "when."

Drake subsequently distinguished himself as Director of the famed Arecibo Observatory, from which he orchestrated the Arecibo Message, humankind's first deliberate microwave transmission to the stars. His astronomical research has led to important discoveries about pulsars and Jovian radio emissions. A retired academic, he is today recognized as the godfather of observational SETI. Much in demand as a speaker at scientific meetings, Frank remains deeply involved in SETI science fully a half-century after Project Ozma, serving as a Director of the SETI Institute in California, and on the scientific advisory board of the nonprofit SETI League.

This, then, is Project Ozma's legacy: it, and Frank Drake, have turned science fiction into credible, respectable science.

VI. "Wow!"

In the years immediately following Project Ozma, several academic institutions in the U.S. and elsewhere commenced their own brief observational SETI experiments. Notable among them was a drift-scan all-sky survey conducted on the Big Ear radio telescope, an instrument constructed at Ohio State University in the late 1960s by pioneering radio astronomer John Kraus. It was to become our longest continually operating SETI experiment, and it turned up the world's best known, though inconclusive, SETI candidate signal.

The detection in question, which was much later featured in an episode of the television series, *The X Files*, traversed the telescope's beamwidth on 15 August 1977. Its name derives from the single word penned in the margin of a computer printout several days after detection, by experimenter Jerry Ehman, when he recognized the significance of the sequence he was examining. Though brief in duration (lasting only 37 seconds at the half-power points) and devoid of any information content, the frequency, bandwidth, amplitude variation, and temporal signature of this artifact precisely matched what SETI scientists would expect from a brief interception of an intelligently generated emission from a technologically advanced extraterrestrial civilization.

Unfortunately, the "Wow!" signal lacked the one characteristic which would have enabled a detailed analysis: repeatability. Seen only once, and never recurring during hundreds of follow-up observations of the same celestial coordinates, the "Wow!" remains an elusive enigma. As the statisticians say, when

N=1, all bets are off. The "Wow!" signal's most significant contribution to SETI science has been to reaffirm that there are emissions abundant, of unknown origin, still awaiting our discovery.

VII. Cyclops—The Greatest Radio Telescope Never Built

In the summer of 1971, Stanford University, the American Institute of Aeronautics and Astronautics (AIAA), and the NASA Ames Research Center jointly convened an academic workshop in Mountain View, California, to explore technologies needed to advance the emerging science of SETI. Jointly chaired by Drs. John Billingham, chief of the NASA Ames life sciences branch, and Bernard Oliver, vice-president of engineering for Hewlett-Packard, the "1971 Summer Faculty Fellowship Program in Engineering Systems Design" drew together a small cadre of the country's leading experts in microwave engineering, signal processing, radio astronomy, and planetary science.

Their mission was deceptively simple: to design (on paper) the world's most capable and advanced radio telescope array, capable of detecting intelligently generated microwave emissions from anywhere in the Milky Way galaxy.

The result of this ambitious study was Project Cyclops, a phased array which was ultimately to grow to 900 dishes, each 100 meters in diameter, driving receivers covering the entire microwave window, the region of the electromagnetic spectrum where Earth's atmosphere and ionosphere are most transparent to incoming, communicative photons.

To nobody's great surprise (since its total cost would very quickly approach the Gross Planetary Product), the Project Cyclops telescope was neither funded nor constructed. Instead, the Project Cyclops team produced something even more important—a 243-page volume detailing all of the engineering considerations which such an ambitious project would entail. That opus, *Project Cyclops*, was published by NASA in a limited (10,000 copy) run, and found itself on the bookshelves of every active and budding SETI technologist of the 20th century.* It became the bible of a whole generation of future SETIzens, including the present author.

To this day, Cyclops continues to inform and inspire SETI technologists. In 1996, on the 25th anniversary of the Cyclops Summer, *Project Cyclops* was reprinted in its entirety by the nonprofit SETI League and SETI Institute. Al-

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* Bernard M. Oliver and John Billingham, *Project Cyclops: A Design Study of a System for Detecting Extraterrestrial Intelligent Life* (Prepared under Stanford/NASA/Ames Research Center 1971 Summer Faculty Fellowship Program in Engineering Systems Design), NASA Technical Report CR-114445, 1971.

though the specific technologies outlined therein have long been eclipsed by advances in the state-of-the-art, the message of Project Cyclops remains current and vital: those of us who contemplate interstellar contact can, and should, continue to learn, to labor, and to dream.

VIII. The NASA Years

In addition to the volume it produced, Project Cyclops also motivated the formation of NASA's short-lived SETI program, based at the Ames Research Center in Mountain View. Modestly funded at perhaps 5 cents per U.S. citizen per year (totaling about 12 million U.S. dollars a year, a sum very much at the noise level of the federal budget), NASA's SETI office was initially chaired by John Billingham, and subsequently by Barney Oliver, upon his retirement from Hewlett Packard.

Although the NASA SETI office never seriously contemplated building a Cyclops array, they proceeded to develop the hardware, software, and protocols necessary to conduct meaningful and scientifically valid searches from a number of existing radio telescopes.

IX. SETI's Golden Fleece Award

From the start, the NASA SETI office was not without its critics. One of the most outspoken (and, sadly, influential) opponents of government-funded SETI research was William Proxmire, a U.S. Senator from the state of Wisconsin. Starting in 1975, Proxmire became famous for instituting the Golden Fleece Award, a dubious honor which he bestowed upon government projects which he deemed to be wasteful of public funds.

After issuing one such "award" to the NASA SETI office, Proxmire introduced an amendment into the 1982 NASA budget that effectively terminated NASA's nascent SETI efforts. It was only through concerted lobbying by famed astronomer and science popularizer Carl Sagan that outright termination of NASA SETI was temporarily averted. However, a similar amendment to the 1994 budget by Senator Richard Bryan terminated NASA's SETI efforts for good. "We've spent millions of dollars," wrote Bryan, "and not one single little green man has stepped forward, saying 'take me to your leader.' This proves that they are not there."

X. Birth of the SETI Institute

With NASA's SETI effort coming under political fire, John Billingham helped to facilitate a transition from government funded to privatized SETI research, which continues into the 21st century.

In the early 1980s, Tom Pierson, an Aeronautical Engineering graduate from the University of Oklahoma, was working as a grants administrator at San Francisco State University where he helped adjunct Professor Charles Seeger obtain research funds for the new SETI project headquartered at NASA's Ames Research Center, an hour's drive to the south. Intrigued, he made a proposal to project participants Barney Oliver, John Billingham, and Jill Tarter, suggesting a more efficient way to organize the NASA efforts.

Pierson laid out the benefits—both organizational and financial—of setting up a nonprofit entity, dedicated to the research. In this way, the administrative and other costs associated with the project could be kept low, and more of the budgeted monies could go to the science.

Finding broad agreement with his idea, Pierson completed the paperwork in the fall of 1984, at which point the nonprofit SETI Institute became a reality. They continue to this day to be the planet's most visible proponents and practitioners of privatized SETI research.

XI. Bookends

Our brief overview of SETI science's first quarter century in the U.S. thus starts optimistically, with Cocconi and Morrison's landmark paper "Searching for Interstellar Communications" in 1959, and ends appropriately with the formation of the SETI Institute in 1984. But, SETI is the science which refuses to die. Significant progress has been made in the thirty years since (to be detailed in future papers), in search of an answer to that fundamental question which has haunted humankind since first we realized that the points of light in the night sky are other suns: "Are we alone?"